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INVESTIGATION INTO THE ANGULAR CORRELATION OF INTERNAL-CONVERSION ELECTRONS

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[Figure is appended.]

The study of angular correlation of internal-conversion electrons emitted during two consecutive transitions of the nucleus is of interest in the investigation of the transformations of nuclear isomers. By this study one can determine the existence of multiplets in nuclear emissions and the angular moments of isomeric nucleii (1)

The present work represents an experimental investigation that was conducted into the angular correlation of conversion electrons of Br^{80*}.

This isomer was chosen because our previous experiments (2) showed that the nucleus of Br^{80*} transfers to its ground state in two successive transitions, in which both of these transitions are strongly converted. The excitation energy of the first level $Br^{80'}$ equals 37 Kev, while the second Br^{80*} is 85 Kev. The general effect caused by K and L-electrons of internal conversion of the first and second transitions was investigated.

The question of angular correlation of conversion electrons in two consecutive transformations of a nucleus was theoretically considered by V. B. Berestetskiy (3).

The angular correlation of conversion electrons of bromine was measured with the help of the apparatus shown in the appended figure. The radioactive preparation P was placed in a glass vessel evacuated to 65 mm Hg. The block-type counters A, B, C operated at this pressure.

The number of coincidences in any pair of counters was measured by a two-channel amplifier with a resolving time of $5 \cdot 10^{-6}$ sec. The number of pulses in each separate counter was recorded by a conversion device with the ratio 1:16.

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The number of coincidences caused by internal-conversion electrons recorded by counters B, C or A, B and A, C, whose axes were inclined 75° and 150°, was measured to determine angular correlation. Further, these coincidences N_{AC} and N_{BC} were related to the number of conversion electrons M_A and M_B, recorded by counters A and B. The value $K = \frac{N_{AC}}{M_A} : \frac{N_{BC}}{M_B}$ which had to differ from unity, because of the presence of correlation, served as a measure of angular correlation.

The number of internal-conversion electrons recorded by the counters of the apparatus was determined by the absorption method. The experiment was conducted in two variations. In the first case, the radioactive preparation of bromine was deposited by the method of spinning it out of activated ethyl bromide onto both sides of silver disk 9 mm in diameter and 60 mg/sq cm thick. The layer of radioactive preparation was less than 0.1 micron thick.

Verifying tests showed that the radiation intensity of both sides of the disk differed by not more than 3%. Then one side of the silver disk was covered with a cellophane coating 3.7 mg/sq cm thick. A 180° rotation of the preparation around a vertical axis permitted the internal-conversion electrons to be absorbed in the cellophane filter instead of being recorded by the counters.

In the second case, the radioactive preparation of bromine was deposited by the above method on one side of aluminum foil 4.9 mg/sq cm thick. This aluminum backing also served simultaneously as a filter of internal-conversion electrons. The necessary filtration was obtained the same way by rotation of the radioactive preparation through 180°. The windows of the block counters were covered by cellophane film 0.3±0.05 mg/sq cm thick to absorb Auger electrons and to eliminate entrainment of discharges from counter to counter.

The number of coincidences N_e caused in any pair of counters by internal-conversion electrons of Br^{80*} and $Br^{80'}$ was determined by the relation:

$$N_e = (N - N^f) - (N_c - N_c^f) - (N_{III} - N_{III}^f) - N_{se}$$

where N, N^f are the total number of recorded coincidences without a filter and with a filter 5 mg/sq cm thick; N_c and N_c^f are the number of chance coincidences under these same circumstances; N_{III} and N_{III}^f are the number of coincidences due to the radiation of Br^{82} (T equals 34 hr); N_{se} is the number of coincidences from scattered conversion electrons.

The number of chance coincidences was determined with respect to the charges of the counters and data for the resolving capacity of the apparatus. The number of coincidences caused by Br^{82} and extrapolation to the necessary time. Special experiments showed that N_{se} could be disregarded.

In the determination of the number of coincidences with respect to the above-indicated differences, it was essential that those coincidences due to scattered hard beta electrons, gamma rays, Compton effect, etc., be excluded.

Seven series of measurements were carried out; six with silver backing and one with aluminum. In the experiments, counter C was normally fixed and coincidences N_{AC} and N_{BC} were measured, but a series of experiments was also carried on in which counter A was fixed and coincidences N_{AB} and N_{AC} were measured.

The data of all series agreed within the limits of statistical error in the experiments. The following values were obtained from the measurements:

$$(N_e/M_e)\,150° = 3.54 \pm 0.27 \cdot 10^{-3},$$
$$(N_e/M_e)\,75° = 2.17 \pm 0.16 \cdot 10^{-3}.$$

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The value K determining the angular correlation thus turns out to equal 1.63 ± 0.24.

To be sure that the obtained value K differing from unity was caused by angular correlation of conversion electrons of Br^{80*} and $Br^{80'}$, rather than by some other forms of coincidences, a series of control experiments was conducted, in which, first of all, measurements of coincidences were taken under identical conditions with radioactive Br^{82}, for which the value of K obtained was a little less than unity.

Further experiments were conducted with a preparation of Ra (D + E) and with an external source of gamma rays. Besides this, a control experiment was carried out with a Br^{80*} preparation whose surface formed an angle of 37.5° with the axis of the middle counter. The filter was turned to the side of counter C. Under these conditions unfiltered radiation struck counters A and B, and filtered radiation struck C. Coincidences were measured between counters A, C and B, C

The values obtained for K in all the control experiments were equal to unity within the limits of error in the experiment.

On the basis of the effect obtained for the angular correlation of internal-conversion electrons of Br^{80*} and $Br^{80'}$, it is possible to make the following conclusions:

1. The mechanical moment of a nucleus of $Br^{80'}$ possessing excitation energy of 37 Kev is not equal to zero, since the angular dispersion of internal-conversion electrons would be isotropic if the moment of this nucleus equaled zero.

2. The lifetime of the intermediate nucleus $Br^{80'}$ is less than 10^{-12} seconds. In agreement with data on the distance between optical lines of hyperfine atomic structure, the angular moment of the nucleus after emission of the first radiation does not succeed in this time in changing its direction in space, which is a necessary condition for the discovery of a correlation (4).

3. It follows from the data on the coefficients of internal conversion that the $Br^{80'}$ nucleus transfers to the ground state with doublet radiation. The nature of the radiation, however, cannot be determined from this data. Computations with Berestetskiy's formulas show that if radiation of a magnetic character is emitted in the transition of a $Br^{80'}$ nucleus to the ground state, then the quantity K should be less than unity. Calculations with these same formulas for electrical radiation lead to a value of K greater than unity, which agrees with the result of the test. On the basis of this, it is necessary to conclude that the radiation in question is electrical.

4. The experimental value of the angular correlation of internal-conversion electrons can be utilized to determine the angular moment of the metastable n nucleus of Br^{80*}. To do this, one must compare the experimental data obtained with theoretically computed data for various possible numerical values of the mechanical moment of bromine nuclei in their ground and excited states.

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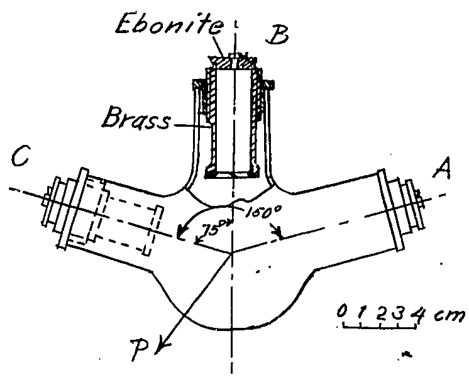
/Appended figure follows./



Counter Apparatus

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